RECENT FORAMINIFERA FROM THE CONTINENTAL SHELF AND SLOPE OFF KAIKOURA, NEW ZEALAND

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ABSTRACT

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A study of foraminiferal distribution off Kaikoura indicates miliolids living at shallower depths on the north side of Kaikoura Peninsula than on the south; arenaceous genera are more common to the south. Samples from bathyal depths show little difference in faunal composition north or south of the peninsula. Occurrence of two species of warm water planktonic foramininfera *Hastigerina pelagica* (d'Orbigny) and *Pulleniatina obliqueloculata* (Parker & Jones) are reported.

KEYWORDS: Recent foraminifera - planktonic - benthonic - Kaikoura - scanning electron micrographs.

INTRODUCTION

Few studies of the distribution of Recent foraminifera have been undertaken in New Zealand to date, with most concentrating on northern regions (*e.g.* Hulme 1964, Thompson 1975, Hayward 1981, 1982a, 1982b, 1983, 1990, Hayward & Grace 1981, Hayward *et al.* 1984, Hayward & Grenfell 1994, Hayward & Hollis 1994, Hayward *et al.* 1994, Hayward & Triggs 1994). Studies of the foraminifera in Cook Strait (Vella 1957), from the continental shelf and slope off southern Hawkes Bay (Lewis 1979) and in Milford Sound (Kustanowich 1964) give additional, more southern data. Hedley *et al.* (1965) redescribed faunas collected on cruises by HMS `Challenger' (1874), `Terra Nova' (1911) and `Discovery' (1932), referring in particular to descriptions made by Brady (1884) and Heron-Allen and Earland (1922). Hedley *et al.* (1967) described intertidal foraminifera from eight widely separated samples around the New Zealand coastline.

METHODS

A cruise in December 1982 by RV `Tangaroa' (no. 1140, Kaikoura Benthos `82) presented the opportunity to collect samples for a study of the foraminiferal distribution off the Kaikoura Peninsula. Bathymetry to the south of the peninsula indicates a narrow shelf with a deep canyon leading off to the south east, and to the north of the peninsula a wider, more gently sloping shelf region occurs. Two main transect lines were undertaken, one north, the other south of the peninsula. Of the total of 58 stations occupied during the cruise, 28 were sampled for foraminifera (Fig. 1). At each site 250 ml of sediment recovered by the dredge was taken and immediately preserved in 70% ethanol. A split of 100 ml of this preserved sample was later treated with Rose Bengal solution, and picked for foraminifera. Stained specimens picked from the residue were regarded as being alive at the time of collection, and comparisons were made between living and dead faunas collected at the same site.

Grain-size analysis of the 28 samples collected for foraminiferal study was carried out in Department of Geological Sciences, University of Canterbury. Sediment distribution, based on the results is shown in Figure 2, and full details of sample position, depth, sediment sorting and composition is given in Table 1. Seven of the samples had insufficient material available for full analysis, and are listed as `mud' in Table 1.

Sample residues and faunal slides have been deposited in the Department of Geological Sciences, University of Canterbury and have been given De-

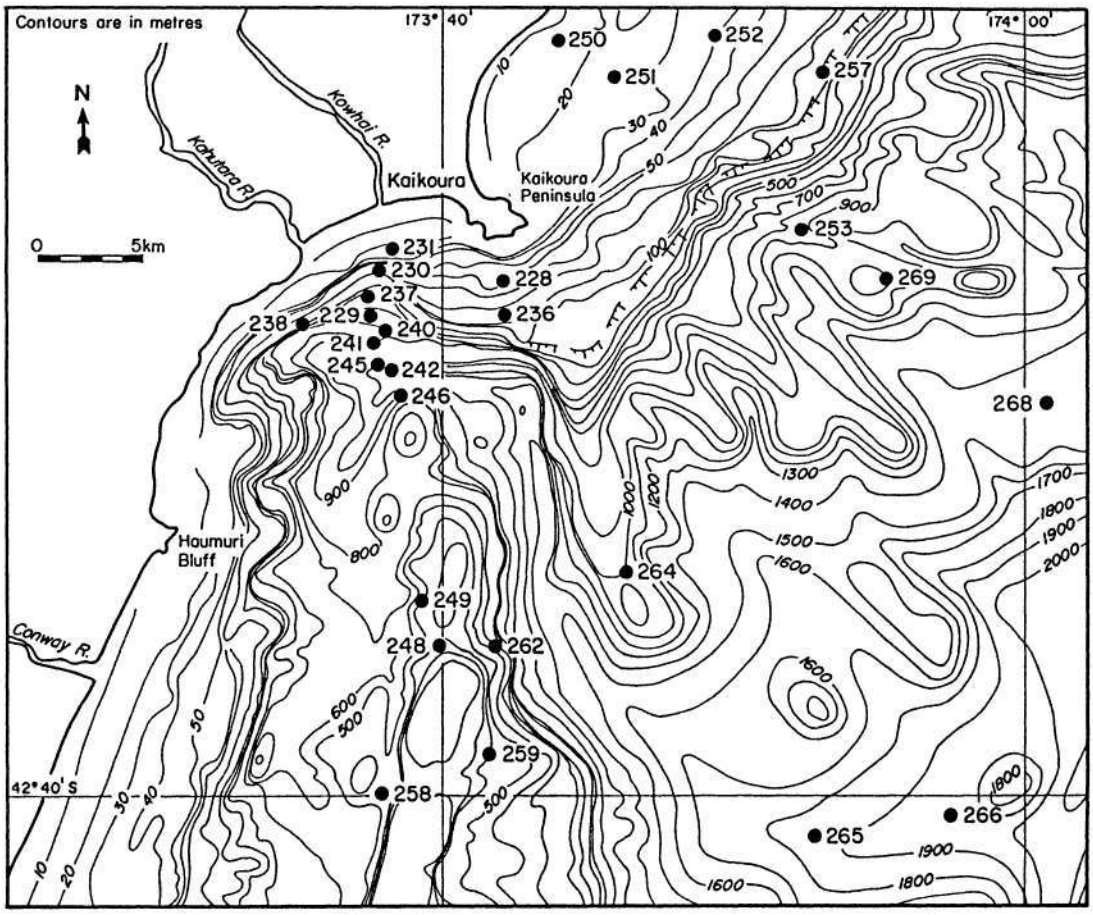

Figure 1. Map showing location of sample points and generalised bathymetry of sea floor off Kaikoura. Bathymetry taken from Herzer, R.H. and Carter, L. (1983). (Position of sample 267 not shown, as well outside map area).

partmental microfossil collection numbers. (prefixed by UCF). Original collection numbers are used in this paper since workers in other fields have material from the same sites and retaining the original numbers will allow easy comparison of results. A list giving the original collection numbers and the equivalent UCF number is lodged with the samples. Figured specimens are held in the UCF collection, with catalogue numbers prefixed by FP.

RESULTS

Shallow water dwelling foraminifera already described from more northern waters of New Zealand were found in similar depths off the Kaikoura coast. Table 2 indicates the percentage of the three main foraminiferal suborders for each location, the planktonic percentage and the depth from which the particular sample was taken. Table 3 (north side) and Table 4 (south side) are selected faunal lists and include stained and unstained specimens. Lagenid genera such as *Oolina*, *Lagena* and *Parafissurina* are not listed in the published charts, but data is available from the author if requested. These genera had a sporadic distribution, were rare in any sample and none showed any staining after treatment with rose bengal. Figures 3, 4 and 5 contain photographs of representative benthonic and planktonic species collected during this study.

BENTHONIC FORAMINIFERA

As indicated in Table 3, living benthonic specimens dominant within sandy sediments on the wide gently sloping shelf north of the peninsula at stations 250 (15 m) and 251 (29 m), were *Zeaflorilus parri* (Cushman), *Nonionella flemingi* (Vella),

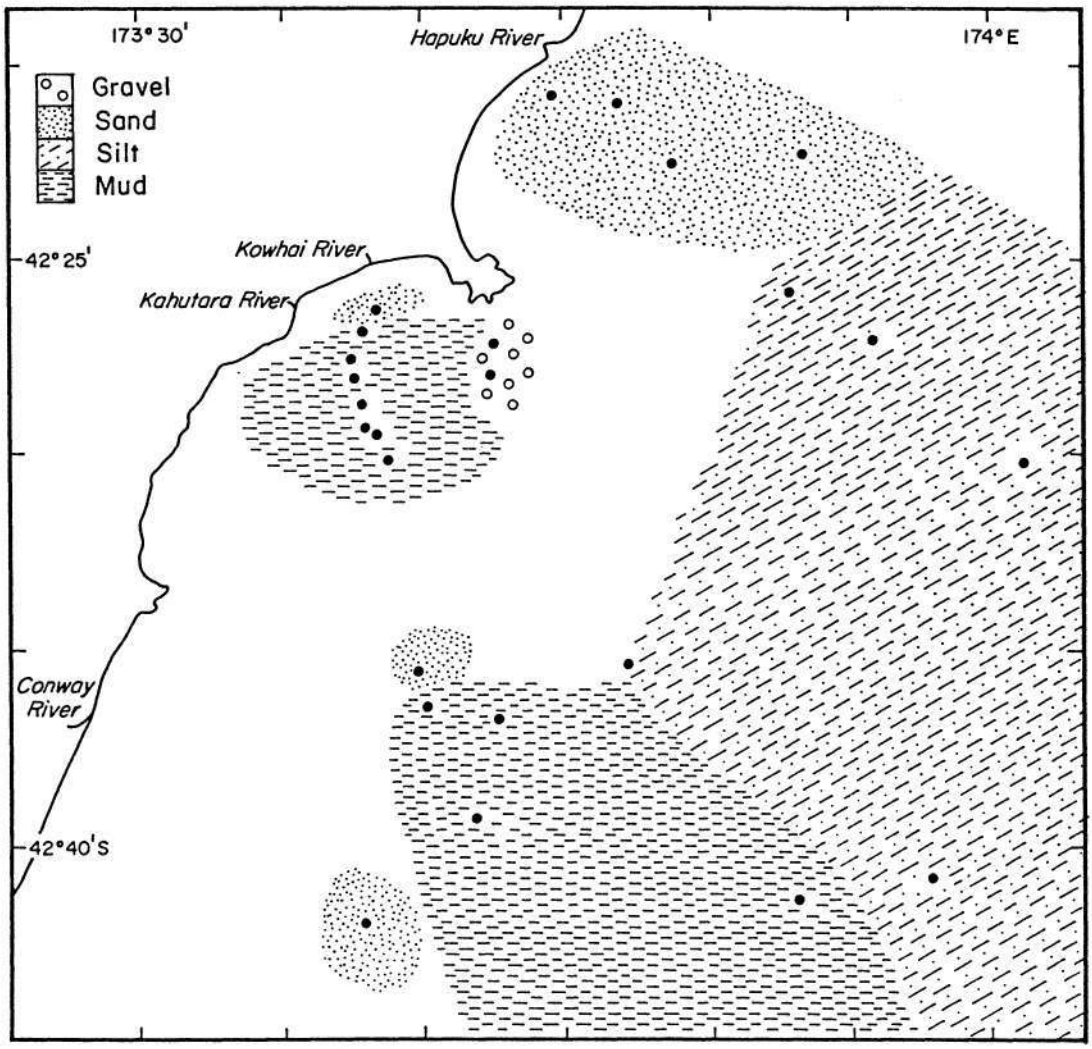

Figure 2. Generalised distribution of sediment types off Kaikoura. Sediment data from Table 1.

Notorotalia inornata Vella, *Elphidium charlottensis* Vella and *Haynesina depressula* (Walker and Jacob), with lesser numbers of *Quinqueloculina triangularis* d'Orbigny, *Q. delicatula* Vella and *Q. incisa* Vella, *Cassidulinoides orientalis* Cushman and *Bulimina marginata* Cushman. In slightly deeper water (station 257, 90 m) the first live specimens of arenaceous forms *Reophax scorpiurus* Montfort, *Ammoscalaris tenuimarginata* (Brady) and *Gaudryina convexa* (Karrer) occur. The three bathyal samples 253 (775 m), 269 (1030 m) and 268 (1280 m) contain more fragile specimens including *Bolivina alata* Seguenzana, *B. numerosa* Vella, *Bolivinita quadrilatera* (Schwager) and *Chilostomella ovoidea* Reuss. In samples from the southern side of the peninsula, live *B. alata* and *C. ovoidea* occur on the shelf below 110 m. As no samples were collected at similar depths in the north, it is uncertain whether specimens of these two foraminfera occur live on the wide sandy shelf there.

On the south side of the peninsula (Table 4), in station 231 (26 m) at a similar depth to stations 250 and 251 and in similar sediment, the live fauna contains just two species; *Zeaflorilus parri* (Cushman) and *Elphidium novozealandicum* Cushman. Arenaceous forms *Reophax scorpiurus*

Table 1. Sample locations, depth of collection, sediment analysis data and type of collecting gear used.

Sample No	Sorting	Sediment Type	Position Lat S	Position Long E	Depth (m)	Gear
U228	VPS	msG	42° 27.2'	173° 42.6'	69	DA
U229	PS	(sc)Z	42° 28.2'	173° 37.4'	525	DA
U230	VPS	(s)cZ	42° 26.8'	173° 37.7'	80-100	DA
U231	WS	S	42° 26.2'	173° 38.3'	26	GSM
U236	EPS	msG	42° 28.0'	173° 42.15'	94	DA
U237	VPS	(s)cZ	42° 27.15'	173° 37.35'	365-420	DA
U238	VPS	(s)cZ	42° 28.55'	173° 34.36'	425-730	DA
U241	VPS	(s)cZ	42° 28.63'	173° 37.60'	795-835	DA
U245	VPS	(s)cZ	42° 29.28'	173° 37.74'	1070-1080	DA
U246	VPS	scZ	42° 30.5'	173° 38.6'	660-670	DA
U249	EPS	gmS	42° 35.17'	173° 39.77'	500	DA
U250	WS	S	42° 20.75'	173° 44.45'	15	DA
U251	VWS	S	42° 21.00'	173° 46.00'	29	DA
U252	PS	zS	42° 20.30'	173° 49.62'	45	DA
U253	VPS	(s)cZ	42° 25.3'	173° 52.9'	775	DA
U257	VPS	czS	42° 22.28'	173° 52.48'	90	DA
U258	EPS	gmS	42° 41.83'	173° 38.05'	110	DA
U264	VPS	scZ	42° 35.20'	173° 47.00'	940	DA
U266	VPS	(s)cZ	42° 40.50'	173° 57.95'	1920-1928	DA
U267	VPS	cZ	42° 37.45'	174° 05.70'	2152-2155	DA
U268	PS	zC	42° 30.0'	174° 01.3'	1275-1300	DA
U240		mud	42° 28.1'	173° 38.20'	550	DA
U242		mud	42° 29.38'	173° 38.16'	1020-1140	TAM
U248		mud	42° 36.40'	173° 39.1'	230-250	DA
U259		mud	42° 39.10'	173° 41.75'	380	DA
U262		mud	42° 36.5'	173° 42.5'	890	TAM
U265		Brown mud	42° 41.1'	173° 53.1'	1753-1762	DA
U269		mud	42° 26.95'	173° 55.55'	1020-1050	DA

EPS = extremely poorly sorted; VPS = very poorly sorted; PS = poorly sorted; WS = well sorted.

g = gravel <-1.0ø; s = sand >-1.0ø - 4.0ø; z - silt 4.0ø - 8.0ø; c = clay 8.0ø - 14ø; m = mud = silt and clay 4.0ø - 14ø.

gzS = gravelly silty sand; (g)zS = slightly gravelly silty sand.

DA = anchor dredge; TAM = Agassi Trawl; GSM = Smith-McIntyre Grab.

Montfort, *Textularia ensis* Vella and *Siphotextularia blacki* Vella appear at station 228 (69 m), together with *Bolivina numerosa* Vella, *Bulimina marginata* d'Orbigny, *B. aculeata* d'Orbigny, *Trifarina bradyi* Cushman and *Discorbinella bertheloti* (d'Orbigny), *Gavelinopsis hamatus* Vella, *Cibicides marlboroughensis* Vella and *Loxostomum karrerianum* (Brady). Apart from *Sigmoilopsis wanganuiensis* Vella and *Siphonaperta macbeathi* Vella, both found live at station 228, no other miliolid genera were found live in waters of depths shallower than 500 m south of the peninsula - a very different situation to that north of the peninsula where all live miliolids were found shallower than 45 m.

Stations 228 (69 m) and 236 (94 m) contained numerous heavy, thicker - shelled specimens. These samples were taken from an area where a wide range of sediment sizes occurred - muddy sandy gravel as recorded in the grain size analysis (Table 1).

As water depth increased, the rugged tests common in shallow water-dwelling forms, gave way to

thinner, more fragile tests, often elongate and flattened rather than discoidal. Little faunal difference was observed in samples from north or south of the peninsula. However sedimentation rate was much higher to the south, where numbers of specimens per unit volume of sediment was much lower than in similar sediment to the north.

Common in samples below 200 m were specimens of *Gaudryina convexa* Karrer, *Bolivina alata* Seguenzana, *Bolivinita quadrilatera* (Schwager), *Bulimina pupoides* Heron-Allen & Earland, *Bulimina marginata* Cushman, *Uvigerina rodleyi* Vella, *Cassidulinoides orientalis* (Cushman) and *Loxostomum karrerianum* (Brady).

Sample U249 (500 m) had the highest diversity of all samples and the largest sized specimens. Some 25% of the total sample were Textulariina, including *Gaudryina convexa* (Karrer), *Dorothia scabra* (Brady) and *Textularia ensis* Vella and just over 10% Miliolina, including *Spiroloculina disparilis* Terquem, *Quinqueloculina miles* Vella and *Triloculina insignis* (Brady). The varied fauna and the large number of living specimens present in the sample suggest optimum conditions for food supply, and reproductive requirements. This sample was collected in an area well known to local residents for good fish catches.

Downslope current movement of material was very evident, especially on the south side of the peninsula, with many tests from shallow water forms being transported into bathyal regions. In the deepest sample examined (U267, 2152 - 2155 m), there were two very worn specimens of *Z. parri*, a common shallow shelf form. The more common

Table 2. Percentage of each suborder, planktonic percentage and depth of collection of samples.

Sample No.	Textulariina %	Miliolina %	Rotaliina %	Planktonic %	Depths (m)
U250	9	17	74	10	15
U231	0	40	60	1	26
U251	8	16	75	5	29
U252	6	18	76	5	45
U228	22	22	56	2	69
U230	23	31	46	10	80-100
U257	18	15	67	15	90
U236	19	6	75	10	94
U258	9	5	84	15	110
U248	17	11	72	25	230-250
U237	14	10	76	50	365-420
U259	13	3	84	45	380
U238	25	12	63	55	425-730
U249	25	13	62	10	500
U229	12	8	79	50	525
U240	15	6	79	55	550
U246	19	9	71	65	660-670
U253	17	8	74	55	775
U241	13	7	80	65	795-835
U262	13	7	79	55	890
U264	19	9	71	55	940
U269	11	4	85	50	1020-1050
U242	9	6	84	50	1020-1140
U245	12	12	75	65	1070-1080
U268	6	3	90	60	1275-1300
U265	14	5	80	70	1753-1762
U266	12	6	82	65	1920-1928
U267	10	6	84	80	2152-2155

Table 3. Selected foraminiferal species,live and dead, north side Kaikoura Peninsula.

station number	250	251	252	257	253	269	268
Depth (m)	15	29	45	90	775	1035	1285
Reophax scorpiurus			c	a/l	c	c/l	c
Haplophragmoides bradyi		r	r	r	c	c	c
Cyclammina cancellata					r	r	
Alveophragmium zealandicum			c	c	c		
Ammoscalaria tenuimarginata		r	r	a/l	c/l	c	
Textularia ensis				c	c		
T. porrecta			r				
Siphotextularia blacki				a	c		
Trochammina nana	r		r	c	r	c	
Gaudryina convexa				a/l	c	c	
Quinqueloculina colleenae				r			
Q. cooki			r				
Q. delicatula	c/l	r	c/l	a	r		
Q. incisa	c/l	c	c/l	a	r		
Q. suborbicularis		r	c/l	a			
Q. triangularis	c/l	c	c/l	c	r	r	
Massilina tenuis	r	r		c	c	c	
Pyrgo ezo				c	c	c	c
Biloculina pisum				c			
Sigmoilopsis wanganuiensis		r	r	a		r	
Siphonaperta macbeathi				c			
Miliolinella vigilax		r		r			
Lenticulina gibba				r			
Robulus vortex	r						
R. calcar				r			
Plectofrondicularia advena							r
Sphaeroidina bulloides	r			c	a/l	c	c
Bolivinita quadrilatera	r				a/l	c/l	c
Bolivina alata					c/l	c	
B. apicularis				r		r	
B. numerosa		r	r	a	a/l	c/l	
B. parri	r	r	c	c		r	
B. spathulata	r			r			
Bulimina aculeata					a/l	a	c
B. exilis						c	r
B. marginata	c/l	r	c/l	a/l	a/l	r	
B. pupoides							c
B. subreticulata						c	
Cassidulinoides orientalis	c/l	c/l	a/l	c	a/l	c	
Virgulopsis turris	r		c/l				
Uvigerina peregrina		r			a/l	c	a
Trifarina bradyi	r		c/l	a/l	a	c	
Buccella frigida	r	r	r	r		r	
Discorbinella bertheloti	r	r	r	c	a	r	

Table 3. (continued)

Station number	250	251	252	257	253	269	268
Depth (m)	15	29	45	90	775	1035	1285
Gavelinopsis hamatus	r	r	c/l	c	c	r	
G. lobatulus				c		r	
Elphidium charlottensis	a/l	c/l	c/l	c	r	r	
E. novozealandicum		r					
Haynesina depressula	a/l	r	c/l		r	r	
Notorotalia finlayi			c/l	c	c		
N. inornata	c/l	r		c			
N. zelandica		r	c/l	c	c	c	r
Eponides tenera				r	r	r	c
Planulina wuellerstorfi				r	r		
Cibicides marlboroughensis		r	r	c	c	r	
Dyocibicides biserialis		r	c	r			
D. primitiva			c	r	r		
Loxostomum karrerianum		r	c	a/l	c/l	c	
Chilostomella ovoidea				r	a/l	c/l	a/l
Astrononion novozealandicum	r	c/l	a/l	r			
Nonionella flemingi	a/l	a/l	c/l	c	c	r	
N. scaphum		r			r	r	
N. turgida					r	r	
Zeaflorilus parri	a/l	a/l	a/l				
Pullenia bulloides					c		c
P. quinqueloba				c			
Anomalinoides spherica			c/l	a/l	c		r
Globigerina bulloides	c	r	c	a	a	a	a
G. quinqueloba	c	r	c	a	a	a	a
Globorotalia hirsuta				r			
G. inflata	c	r	c	a	a	a	a
G. scitula						c	c
G. truncatulinoides	r			a	a	a	a
Neogloboquadrina pachyderma	c	r	c	a	a	a	a
Pulleniatina obliqueloculata	r					r	r

a = abundant, c = common, r = rare, l = live.

living benthonic species in these deep water samples below 1000 m (Stations 266 - 269) were *Reophax scorpiurus* Montfort, *Pyrgo serrata* (Bailey), *Bolivinita quadrilatera* (Schwager), *Bulimina aculeata* d'Orbigny, *Chilostomella ovoidea* and *Pullenia quinqueloba* (Reuss). *Loxostomum karrerianum* (Brady) was also present.

PLANKTONIC FORAMINIFERA

Distribution of planktonic foraminifera around New Zealand was discussed by Hayward (1983). He identified 26 species (70%) of the world's planktonic taxa living in waters around New Zealand between latitudes 28°S and 52°S. Kaikoura is situated in the Transitional Province, "characterised by abundant *Globorotalia inflata* (d'Orbigny) together with a diverse fauna of mixed cool and warm water forms." His Figure 6 indicated latitudinal ranges for these 26 species. Specimens of *Hastigerina pelagica* (d'Orbigny) (Station 267) and *Pulleniatina*

Table 4. Selected foraminiferal species, live and dead, south side Kaikoura peninsula.

Station number	231	228	230	236	258	248	259	237	249	229	240
Depth (m)	26	69	90	94	110	240	380	390	500	525	550
Ammodiscus incertus						r			r		
Reophax scorpiurus		c/l	a/l	a/l	c	a/l	a/l		a/l		r
Haplophragmoides bradyi		c	a/l	a	c		r	a/l	r	a	c
Cyclammina cancellata									r		
Alveophragmium zealandicum		r				a	c/l		a/l		
Ammoscalaria tenuimarginata			c/l	a/l		c	c/l		a/l		c/l
Textularia ensis		c/l		c	c	a					
T. porrecta			r	r							
Siphotextularia blacki		c/l		c	c		c		r		r
S. mestayeri					c	a			r		
Trochammina nana			c/l		c			c	r	c	
Dorothia scabra							c				
Gaudryina convexa		r		a/l		c	c	a/l	a/l	a/l	c/l
Spiroloculina disparilis		r									
Quinqueloculina colleenae				r							
Q. cooki		r									
Q. delicatula		c		r	c			r		r	
Q. incisa	c	c	c						c	r	
Q. kapitiensis			c					r			
Q. lamarkiana		r									
Q. lata	c										
Q. miles									c		
Q. suborbicularis	c	c						c			r
Q. triangularis	c		c	r		r		c	c		
Massilina tenuis			r	r	c	c		r	c	r	r
Pyrgo depressa											
P. ezo		c					r		c/l		
P. serrata						r			r/l		
Biloculina pisum						c	r		r/l		
Sigmoilopsis wanganuiensis		c/l		a	c	a	c				
Siphonaperta macbeathi		c/l	r			a	a		a/l		r
Miliolinella vigilax	c	c		r	r	c				r	
Triloculina insignis		r							r/l		
Lenticulina costatus						r			r		
L. gibba		r			r	c/l			r		
Robulus calcar				r		c			r		
R. vortex						c	c		r		
Plectofrondicularia advena									r/l		
Sphaeroidina bulloides	r	r		a	c	c	c/l	c	r	c	a
Bolivinita quadrilatera						c	c		c/l		
Bolivina alata					c/l	a/l	a/l	a/l	c/l	a/l	a/l
B. apicularis		r			r	r					
B. numerosa		c/l		a	c	c	c	r	c	c	c
B. parri	r	r	r	c	r	r		r	r	r	r
B. spathulata				r				r			c
Bulimina aculeata		c/l	r				c		c/l		c/l
B. costata									c		
B. echinata							r		c		
B . exilis										r	

Table 4 (continued).

Station number	238	246	241	262	264	242	245	265	266	267
Depth (m)	4-700	665	810	890	940	1040	1080	1760	1920	2155
Ammodiscus incertus										
Reophax scorpiurus		a/l	c	c/l	a/l	c		a	c/l	a
Haplophragmoides bradyi	r	c/l	c	r/l	r	c	c	r	r	c
Cyclammina cancellata					r					
Alveophragmium zealandicum	c/l	c/l			r			r	r	
Ammoscalaria tenuimarginata		a/l	c		c/l	c		r		
Textularia ensis		c	r				r			
T. porrecta		r								
Siphotextularia blacki		c					r			
S. mestayeri		c								
Trochammina nana	r	c/l	c	r	r	a	c	c	r	c
Dorothia scabra										
Gaudryina convexa	c/l	c	c	c	r	a	c/l	c	r	
Spiroloculina disparilis										
Quinqueloculina colleenae										
Q. cooki										
Q. delicatula		r					r			
Q. incisa		r								
Q. kapitiensis										
Q. lamarkiana							c			
Q. lata			r							
Q. miles										
Q. suborbicularis	r		r							
Q. triangularis		r		r		a		r	r	r
Massilina tenuis		r	r	r		c	c	r		r
Pyrgo depressa							r		r	
P. ezo					c			r	r	
P. serrata					r/l					r
Biloculina pisum										
Sigmoilopsis wanganuiensis	r									
Siphonaperta macbeathi		r	r				r	r		
Miliolinella vigilax	r			r			r		r	
Triloculina insignis										
Lenticulina costatus										
L. gibba										
Robulus calcar										
R. vortex										
Plectofrondicularia advena					r					r
Sphaeroidina bulloides	c/l	c	c/l	r	c/l	c	c/l	a		c
Bolivinita quadrilatera		c/l	r	c/l	c/l			a	c/l	a/l
Bolivina alata	c/l	c/l	a/l			c	c/l	r		c
B. apicularis				r				r		
B. numerosa	r	c/l	r	r		r	r			
B. parri		r					r	r		r
B. spathulata		r		c		r	c	r		
Bulimina aculeata		c/l	r	r	a/l		c/l	a	c	a/l
B. costata								c	c	a/l
B. echinata										
B . exilis								c		

Table 4 (continued)

Station number	231	228	230	236	258	248	259	237	249	229	240
Depth (m)	26	69	90	94	110	240	380	390	500	525	550
B. marginata	r	c/l		a	a/l	a	c	c	c/l	c	a/l
B. pupoides			r		a/l	c	c/l	a/l	c/l	c	c/l
B. subreticulata											
Cassidulinoides orientalis	c	a/l		a	c/l		a/l	a/l	a/l	a/l	a/l
Virgulopsis turris								r	r		r
Uvigerina peregrina					c	a/l	a/l		c/l		
U. rodleyi					c						
Trifarina bradyi		c/l	r	a	a	a	a/l	r	c	c	r
Discorbinella bertheloti	r	c/l	r	c	c	r		r		r	r
Gavelinopsis hamatus	r	a/l		a	r			r		r	
G. lobatulus					c				r		c
Laticarinina halophora					r	r	r		r		
Elphidium charlottensis	c	r	r	c	r		r	r	r	r	r
E. novozealandicum	c/l										
Haynesina depressula								r			r
Notorotalia finlayi	a	c	c	a			c	r	a/L	r	c
N. inornata		c		a	c	c					c
N. zelandica	a	a/l		a	c	c	r		c/l		r
Eponides tenera					r		c		r		
Planulina wuellerstorfi				c	c	c	c		c/l		a
Cibicides corticatus				c		c			r/l		c
Cibicides marlboroughensis		c/l		a	c	a	c	r	c/l		c
Dyocibicides biserialis				c	c	c					c
D. primitiva	r	c				c		r			
Loxostomum karrerianum		a/l	r	a/l	a/l	a/l	a/l	c	c/l	c	c
Chilostomella ovoidea					c/l	r	a/l		c		
Astrononion novozealandicum		c		c	r	c	r	r	r		r
Zeaflorilus parri	a/l	r	r					r			
Nonionella flemingi	c	c	c	a	r	c	c	c	r	r	r
N. scaphum						r			r		
N. turgida			r		r	r	c	r	r	r	c
Pullenia bulloides				c	c		c		r		
P. quinqueloba				c		r	r				
Anomalinoides spherica		c/l	r	c	r	r			r		
Hoeglundina elegans						c	r		r		
Hastigerina pelagica											
Globigerina bulloides		r	a	a	a	a	a	a	c	a	a
G. quinqueloba		r		a	a	a	a	a	c	a	a
Globorotalia hirsuta					r			r			
G. inflata		r	a	a	a	a	a	a	c	a	a
G. scitula				r			c				
G. truncatulinoides	r			a	a	a	a	a	c	c	a
Neogloboquadrina dutertrei					r		r				
N. pachyderma		r	a	a	a	a	a	a	c	a	a
Pulleniatina obliqueloculata											
Orbulina universa				a	a	a	a	a	c	a	
Biorbulina biloba											

a = abundant, c = common, r = rare, l = live.

Table 4 (continued)

Station number	238	246	241	262	264	242	245	265	266	267
Depth (m)	4-700	665	810	890	940	1040	1080	1760	1920	2155
B. marginata		c/l	r	r	a/l	c	c/l			
B. pupoides	r			c	a/l					
B. subreticulata								r		r
Cassidulinoides orientalis	c/l	a/l	c/l	r		a	a/l	a	r	r
Virgulopsis turris		r					r			
Uvigerina peregrina		c		a/l	a/l			a	r	c
U. rodleyi		c								
Trifarina bradyi	r	a	c/l	c		a	r	c		
Discorbinella bertheloti		c	r	r	r	r	c	r		
Gavelinopsis hamatus		c	r	r			c			
G. lobatulus	r					r	r			
Laticarinina halophora					r					
Elphidium charlottensis	r	r	r			r	r	r	r	
E. novozealandicum						r				
Haynesina depressula		c								
Notorotalia finlayi		c		r						
N. inornata		c	r				r			
N. zelandica				r	c					
Eponides tenera		r		r	r			r	r	c
Planulina wuellerstorfi		c			c/l	r	r			
Cibicides corticatus		c	r		r					
Cibicides marlboroughensis		c		r			r		r	r
Dyocibicides biserialis		r				r				
D. primitiva										
Loxostomum karrerianum	r	a/l	c/l	r		r	r	r	r	
Chilostomella ovoidea					a/l			c	c/l	a/l
Astrononion novozealandicum		c	r				r			
Zeaflorilus parri			r							
Nonionella flemingi	r	c	c	r		r	c	r	r	r
N. scaphum		r	r	r		r	r	r		
N. turgida	r	r	r	r	r	r	r	r	r	r
Pullenia bulloides									c	a
P. quinqueloba		c	r	r						
Anomalinoides spherica		c	r			r	r		r	
Hoeglundina elegans										
Hastigerina pelagica					r					r
Globigerina bulloides	a	a	a	c		a	a	a	a	a
G. quinqueloba	a	a	a	c	a	a	a	a	a	a
Globorotalia hirsuta	r									
G. inflata	a	a	a	c	a	a	a	a	a	a
G. scitula				c	r	r		c	r	a
G. truncatulinoides	a	a	a	c	a	a	a	a	a	a
Neogloboquadrina dutertrei					r			r		
N. pachyderma	a	a	a	c	a	a	a	a	a	a
Pulleniatina obliqueloculata		r				r		r	r	c
Orbulina universa	a	a		c	a	a		a	a	a
Biorbulina biloba								r		

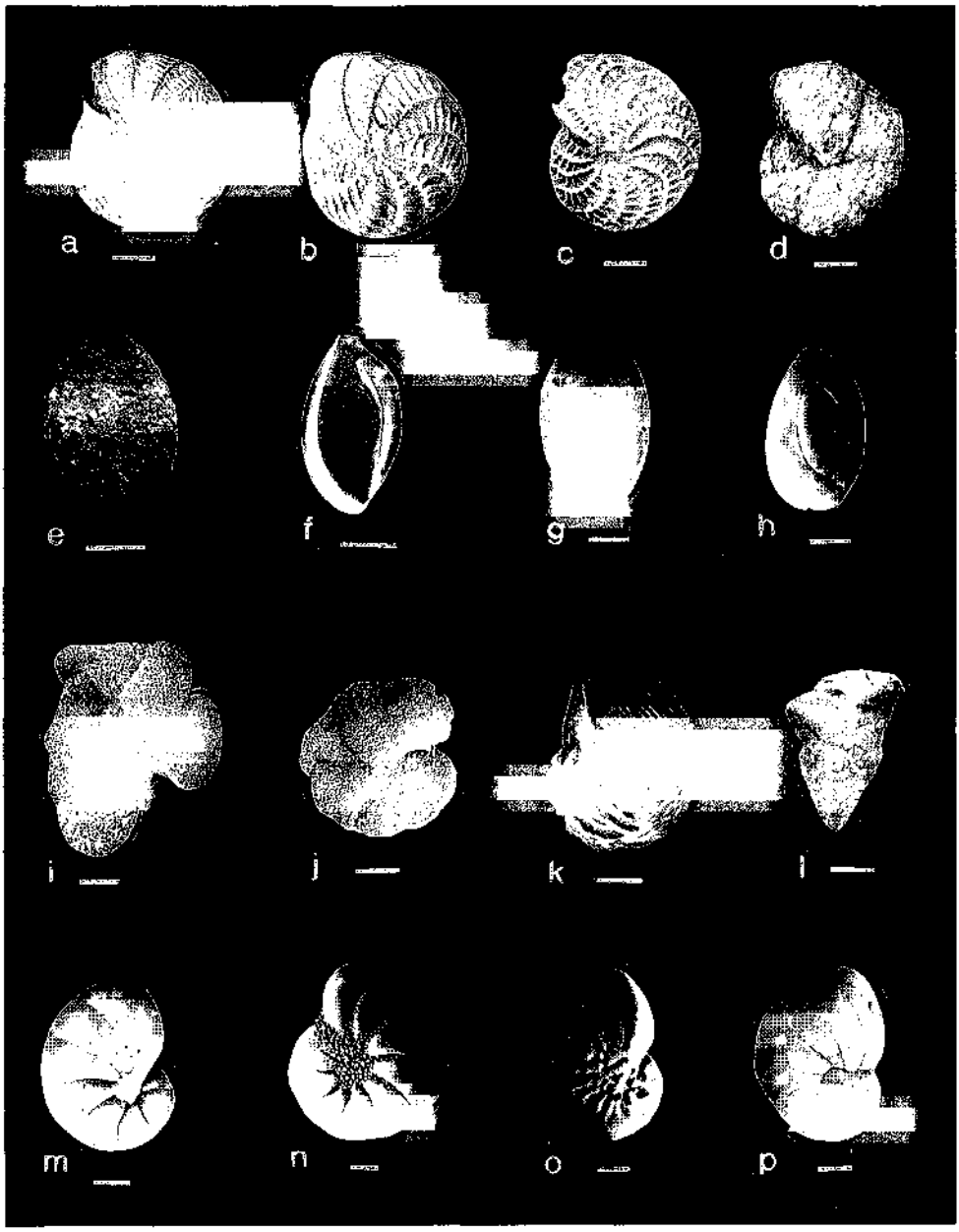

Figure 3.a. *Notorotalia zelandica* Vella bar length represents 100 μm. Station U228. b. *Notorotalia finlayi* Vella 200 μm. Station U228. c. *Elphidium novozealandicum* Cushman 100 μm. Station U231. d. *Alveophragmium zealandicum* Vella 400 μm. Station U248. e. *Sigmoilopsis wanganuiensis* Vella 200 μm. Station U228. f. *Spiroloculina disparilis* Terquem 200 μm. Station U228. g. *Quinqueloculina miles* Vella 100 μm. Station U249. h. *Quinqueloculina incisa* Vella 100 μm. Station U250. i. *Dyocibicides biserialis* Cushman & Valentine 200 μm. Station U248. j. *Cibicides corticatus* Earland 400 μm. Station U236. k. *Lenticulina costatus* Fitchel & Moll 400 μm. Station U248. l. *Gaudryina convexa* (Karrer) 400 μm. Station U236. m. *Nonionella flemingi* (Vella) 40 μm. Station U250. n. *Haynesina depressula* (Walker and Jacob) 40 μm. Station U250. o. *Zeaflorilus parri* (Cushman) 100 μm. Station U250. p. *Zeaflorilus parri* (Cushman) 100 μm. Station U250.

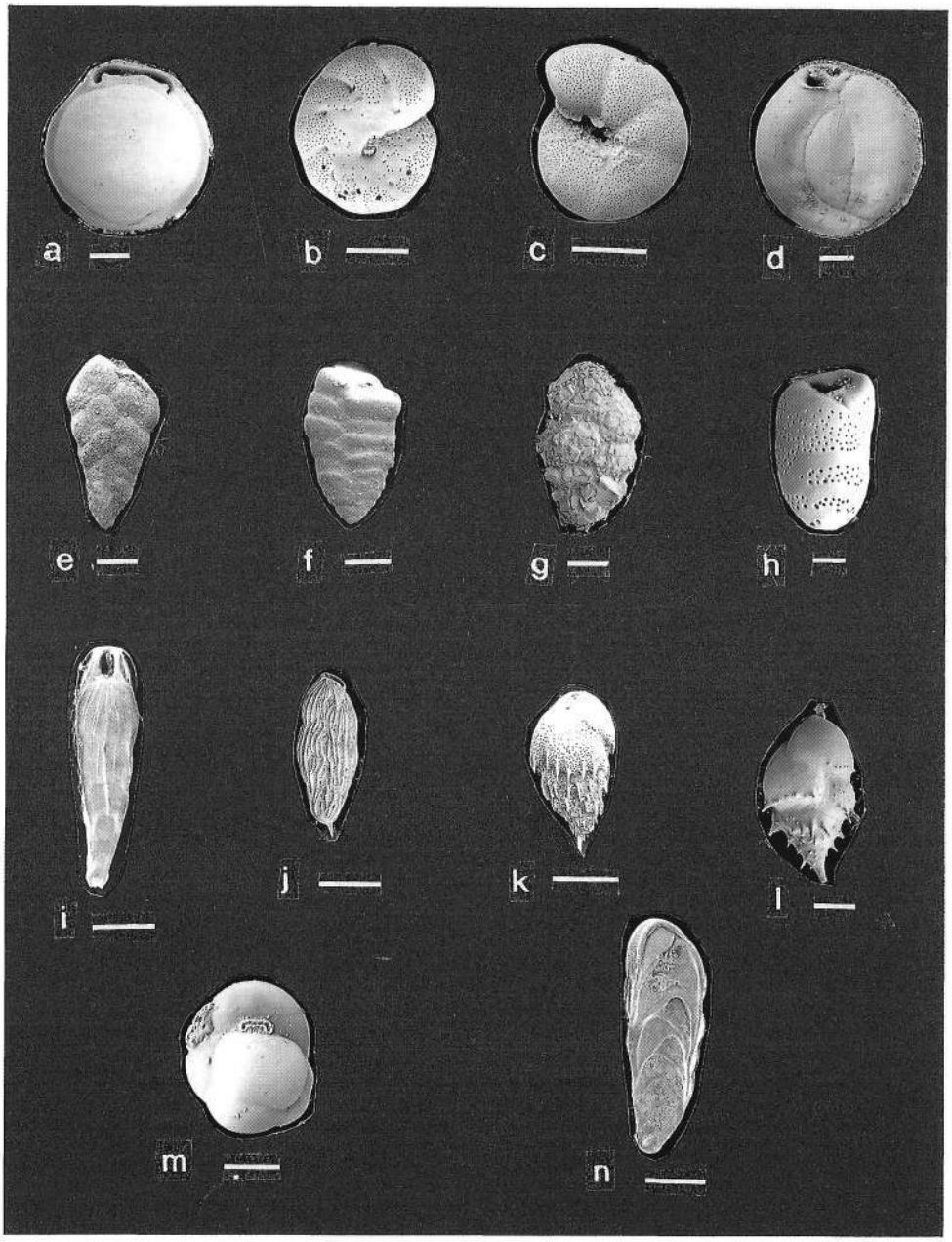

Figure 4.a. *Pyrgo depressa* (Bailey) bar length represents 200 μm. Station U266. b. *Astrononion novozealandicum* Cushman & Edwards 100 μm. Station U257. c. *Anomalinoides spherica* (Finlay) 100 μm. Station U257. d. *Triloculina insignis* (Brady) 400 μm. Station U249. e. *Siphotextularia mestayerae* Vella 200 μm. Station U236. f. *Textularia ensis* Vella 200 μm. Station U228. g. *Dorothia scabra* (Brady) 200 μm. Station U259. h. *Virgulopsis turris* (Heron-Allen & Earland) 40 μm. Station U252. i. *Bolivinita quadrilatera* (Schwager) 200 μm. Station U253. j. *Loxostomum karrerianum* (Brady) 200 μm. Station U228. k. *Bulimina marginata* d'Orbigny 200 μm. Station U257. l. *Bulimina echinata* d'Orbigny 100 μm. Station U249. m. *Sphaeroidina bulloides* d'Orbigny 100 μm. Station U253. n. *Bolivinita quadrilatera* (Schwager) 200 μm. Station U249.

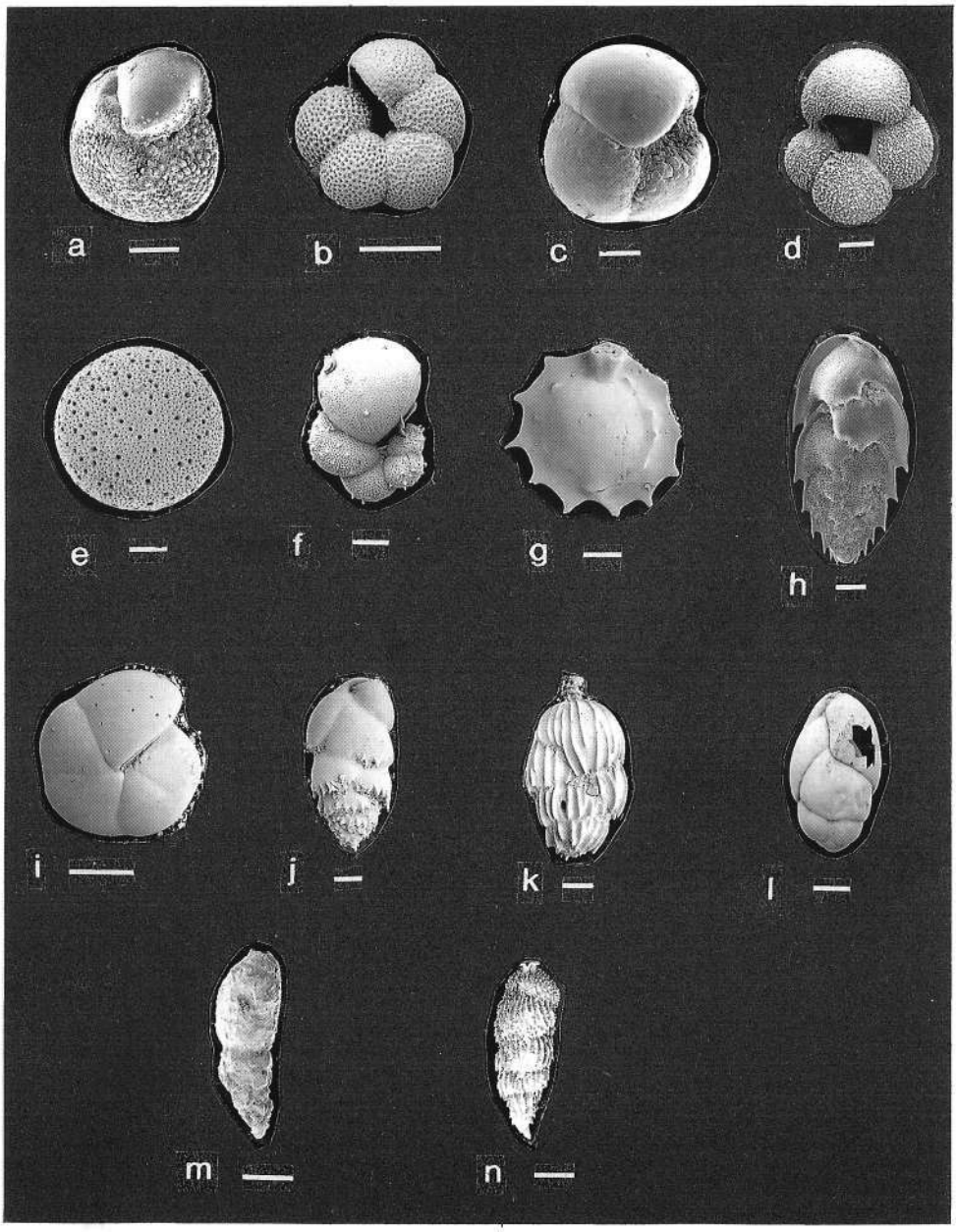

Figure 5. a.*Globorotalia truncatulinoides* (d'Orbigny) bar length represents 100 μm. Station U246.b. *Neogloboquadrina dutertrei* (d'Orbigny) 100 μm. Station U257.c.*Pulleniatina obliqueloculata* (Parker and Jones) 100 μm. Station U267. d.*Globigerina bulloides* d'Orbigny 100 μm. Station U241. e.*Orbulina universa* d'Orbigny 100 μm. Station U264. f.*Hastigerina pelagica* (d'Orbigny) 100 μm. Station U267. g.*Pyrgo serrata* (Bailey) 100 μm. Station U249. h.*Bolivina alata* Seguenzana 100 μm. Station U259. i.*Pullenia quinqueloba* (Reuss) 200 μm. Station U236. j.*Bulimina aculeata* d'Orbigny 100 μm. Station U253. k.*Uvigerina rodleyi* Vella 200 μm. Station U246. l.*Bulimina pupoides* Heron-Allen and Earland 200 μm. Station U258. m.*Reophax scorpiurus* Montfort 400 μm. Station U257. n.*Uvigerina peregrina* Cushman 400 μm. Station U253.

obliqueloculata (Parker & Jones) (Stations 242, 265 - 269) were found during this study, both having been recorded only in more northern waters before this. *P. obliqueloculata* was common at station 267.

Specimens of planktonic foraminifera living in oceanic surface waters generally increase in number with increasing distance from the shore (Boltovsky & Wright 1976). Since increasing distance from the shore usually correlates with an increasing depth of water, the number of planktonic foraminiferal tests in the bottom sediments therefore generally increases with depth. However, there is not an exact correlation. (See Hayward 1979)

As indicated in Table 2, samples with 10% or less planktonic foraminiferal content were from depths of less than 100 m, with the exception of U249 which was dredged from 500 m. U 249 was the sample with highest diversity and largest sized specimens discussed earlier. Samples 257 (90 m) and 258 (110 m), contained more (15%) planktonics than anticipated, which may relate to onshore winds blowing the oceanic water masses closer to shore (Vella 1962). Specimens of planktonic foraminifera in all inshore, shallower water samples were fewer in number, and smaller sized than those in the deeper water samples.

Samples from greatest depths, (U 264, 265, 266, 267, 268 and 269) contained the highest proportion of planktonic foraminifera, 80% of the total fauna in the case of 267, (2152 - 2155 m).

Coiling directions of certain planktonic foraminiferal species have been shown to be dependent on water temperature. In samples collected during this study, specimens of *Globorotalia truncatulinoides* (d'Orbigny) were dominantly sinistrally coiled, and *Neogloboquadrina pachyderma* (Ehrenberg) dextral, confirming earlier work done by Kennett (1976) and Hayward (1983).

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